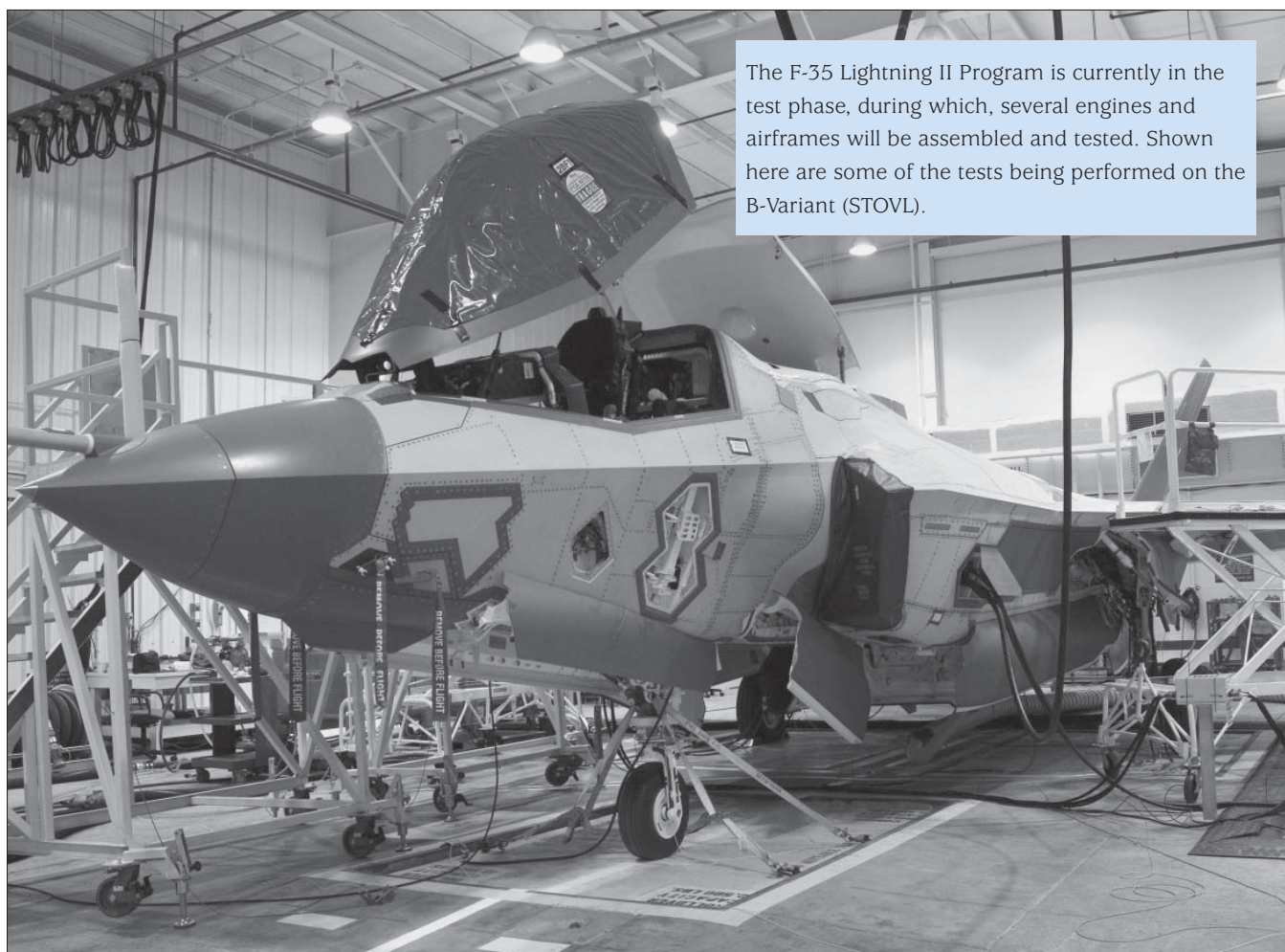


# A Great System Right Out of the Chocks

## How the JSF Delivers Mission Capabilities

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The F-35 Lightning II Program is currently in the test phase, during which, several engines and airframes will be assembled and tested. Shown here are some of the tests being performed on the B-Variant (STOVL).

**A**chieving a usable, valued, and timely capability for the warfighter can be a complex task if you are looking to satisfy everyone's requirements in a single step. Modern-day acquisition programs have found that evolving capabilities to the warfighter can be successful if two factors can be successfully managed: achieving an alignment between the technical maturity of the platform (hardware, software, personnel, etc.) and what the stakeholders feel they

must have in order to provide the best system capability for the particular point in the system's life cycle. The challenge is to fully assess the physical potential of the weapons system and the time-critical needs of the full range of users.

Historically, joint-service acquisition programs have had very mixed results in delivering the desired system to all stakeholder users. The ability to balance the performance

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necessary to execute diverse mission needs, and at the same time, meet established cost and schedule goals, seems almost unobtainable, but the balance is at the core of solving the classic systems engineering problem for your program. Programs such as the F-4 Phantom did obtain some measure of performance success as a fighter/attack system for the Air Force, Navy, and Marine Corps during the Vietnam era. There are other examples—such as the Abrams tank, infantry equipment, and personal protection programs—that have been successfully introduced in a joint fashion. However, the complexity of these systems, the scale of the budgets, and the number and diversity of stakeholders involved do

not compare to the F-35 Joint Strike Fighter (JSF) Lightning II. In the program, we have three Services (Air Force, Navy, and Marine Corps); three aircraft variants based around a core of airframe, avionics, and propulsion technologies; full partners and eight international partners (including the United Kingdom); and dozens of other countries buying the system and/or building major subsystems of the program.

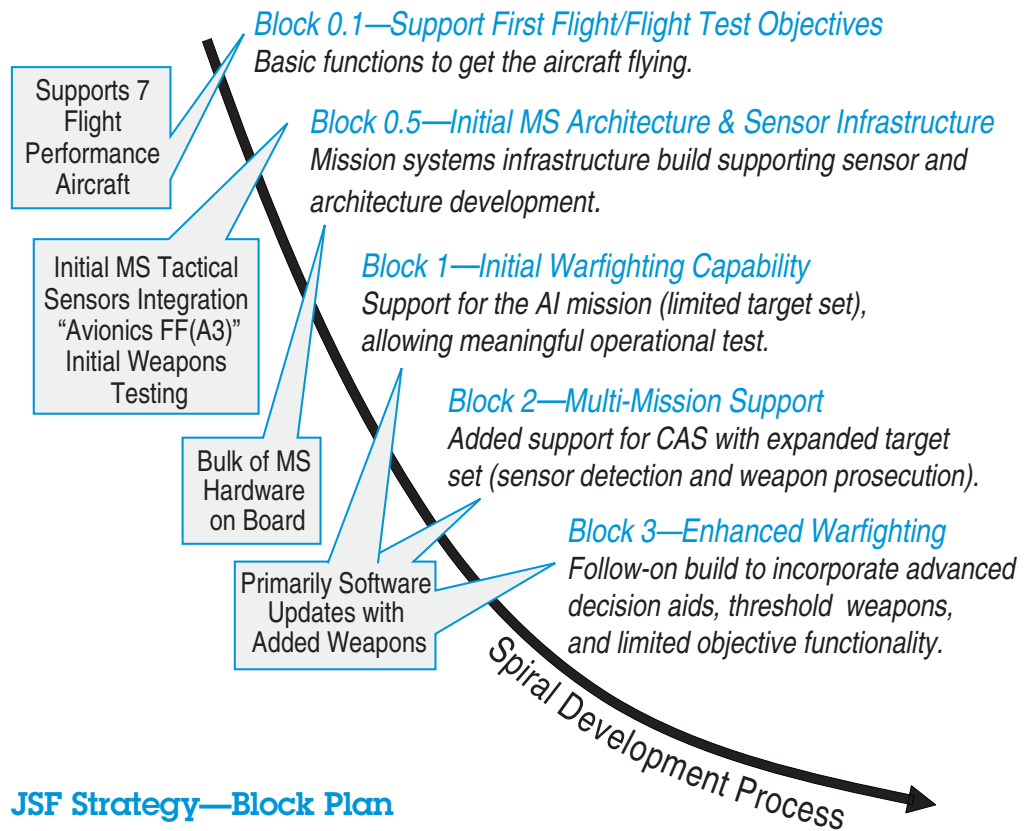
So how is the largest Department of Defense acquisition program in history progressing in managing its technical performance within the bounds of the cost and schedule of its acquisition baseline? Before answering that question, we need to understand some of the background challenges the program has recently had to address and resolve.

## Joint Strike Fighter Development Program

The JSF development program, led by Lockheed-Martin, is tied to a performance-based specification traceable to the program's operational requirements document. The approach to meet these requirements is to follow the hierarchy of the ORD and JSF contract specification and then develop a mission decomposition effort that would yield tiered specifications as follows:

- Tier 1 spec (air system)
- Tier 2 (air vehicle and autonomic logistics systems)
- Tier 3 (e.g., mission systems)

## JSF Strategy—Block Plan



- Tier 4 (e.g., radar)
- Tier 5 & Tier 6 (radar component and subsystems).

In December 2005, a functional baseline system (FBS) audit/reconciliation effort was completed for the JSF contract specification (JCS). The audit focused on the 433 total air system Tier 1 requirements, as well as the Tier 1 (air system) and Tier 2 (air vehicle and autonomic logistics) specifications, to ensure there was clear linkage between them; to ensure traceability to requirements at each tier; and to ensure that they were verifiable. An allocated baseline plan (ABP) audit/reconciliation effort followed the functional baseline effort to complete the linkage, traceability, and verifiable characteristics all the way to the Tier 6 level.

As you might expect, there were some changes made as a result of the effort. In some cases, the efforts were terminated because the linkage was not established; in others, there was additional scope introduced; and in yet others, there was a need to perform additional analyses to determine exactly what was needed to satisfy the requirement. Unfortunately, the unanswered “to be determined” questions prevented the JSF program from completing both the FBS and ABP efforts.

## Significant Pressures

Other pressures were also converging at the same time that made answering the “to be determined” require-



ments all the more important. The program had previously frozen requirements for Block 0.5, Block 1, and Block 2 but was having a difficult time converging upon a recommendation for the final system development and demonstration (SDD) block (Block 3) capabilities. An overview of the Block Plan is shown on the previous page. The program had to complete the translation of mission capabilities to aircraft baselines. The application of a rigorous system engineering discipline was required to resolve which specific missions the initial aircraft delivered to the fleet would be able to accomplish. The program needed to ensure the air system satisfied our most important missions and added only the essential capabilities necessary to our last SDD upgrade. To make matters more complex, the program needed to complete a JCS assessment prior to critical design review 3 (carrier-based variant), and resolve challenges in weapons delivery accuracy and the verification concerns associated with it.

To put this translation of missions to aircraft baselines in perspective, there are a total of 23 missions specified in the ORD. Based upon the priorities the Services provided to the program on mission areas and through combining some missions, there were a total of 12 reference missions decomposed for the final SDD Block 3 analyses. One example of the type of problem that required resolution was that of “tactically significant range.” The JCS states: “The Air Vehicle shall employ stores against targets and threats at tactically significant ranges as described in the classified annex.” So one of the questions answered was

“What is the air vehicle requirement for target location error?” A large number of these questions created a complex dilemma for the program to address.

### Mission Decomposition Analysis Team Formed

The response of the program was to charter the mission decomposition analysis team with the objective of providing the required deliverables necessary to complete the FBS and ABP, and establish the mission capabilities required for SDD Block 3. How the MDAT was to approach achieving these results would require insight and guidance from the program leadership, however.

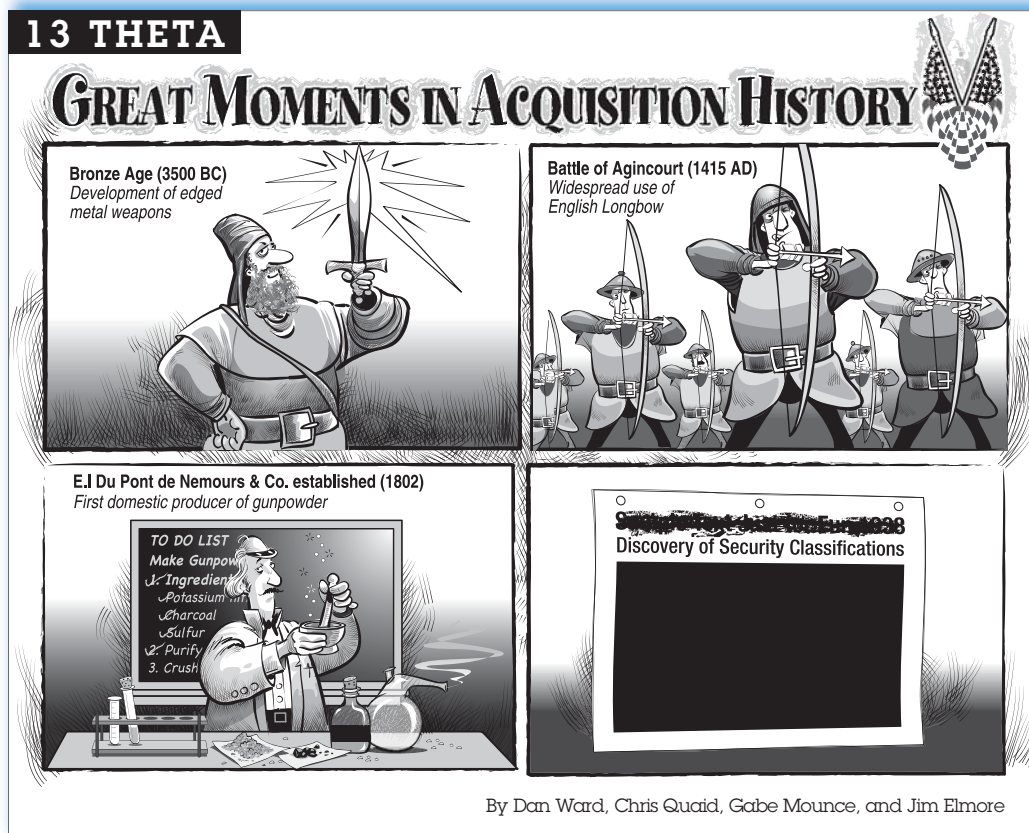
To effectively and efficiently approach their assignment, the MDAT was given a set of objectives from the program leadership to which to align:

- Intelligent use of trade-offs of cost, schedule, and capability
- Prioritization of the missions for Block 3 so as not to trade off real, needed capability for cost and schedule
- Recognition that the program would find other places to reduce cost because cutting capability was not an option
- Admonition not to forget the stakeholders.

To start with, the MDAT was conceived as a true, integrated Lockheed-Martin and JSF program office team effort. Much of the strength of the analysis and its results had to do with the composition of the team. To perform

the mission decomposition analysis, Lockheed-Martin created a cross-integrated project team interdisciplinary group that included expertise from every IPT where required. The government portion of the team was led by a Joint Program Office Air System Requirements representative and included Service operational experts (weapons school graduates) from the Air Force, Navy, and Marine Corps to assist in the peer reviews. An additional factor for the Service experts was their stability; they stayed with the MDAT throughout the entire analysis process.

A total of 23 missions are specified in the ORD.



From those, 12 reference missions were constructed and analyzed in the MDAT. The 12 reference missions were stressing cases for the air system that emphasized the missions that the Services identified as top priorities for JSF.

## Two Products

The mission decomposition team produced two products. The first was a requirements work package (RWP) in the Lockheed-Martin standardized format that was coordinated through all stakeholders. The second was the formal linkage of all requirements between tiers and verification paragraphs in the Dynamic Object Oriented Requirements System. Creation of these products had a direct impact on resolving the to-be-determined questions obstructing the completion of the FBS, ABP, and Block 3 mission capabilities.

The RWP product facilitates coordination and documents changes to multiple design products that are integrated to implement a requirement, a capability, or a function. RWPs:

- Provide support to manage the work required to get a function implemented across multiple products
- Establish acceptance of the responsibility to implement parts of a function
- Identify and document changes to products and designs that implement parts of a function. An RWP may deal with a functional mechanization or a document change or the “arms-around” documentation of the design, analysis, traceability, and verification associated with a requirement.

The life cycle of an RWP began with a selection of the RWP author. The author drafted the RWP, which was then vetted at an internal design peer review. For mission decompositions, this peer review included Lockheed-Martin and Joint Program Office representatives. The next step was the external design review to the Lockheed-Martin/JPO Tier 2 leaders and finally the executive leadership team. Action items were then resolved, and the RWP was approved and changes incorporated.

For each mission decomposition effort the team completed, a tactical timeline was established beginning with the aircraft “fence in,” or readiness to penetrate threat envelopes for a mission. The analysis was concluded at the “fence out” portion of the flight, or when the aircraft had safely egressed from threat envelopes. Each mission phase or segment—“tactical ingress,” “tactical engage,” and “tactical egress”—was further broken down into phase tasks (e.g., detect, track, identify, engage, get battle damage indication). Each phase task was further broken down to analyze what was involved with its execution (e.g., select synthetic aperture radar map, start SAR mapping, end SAR mapping, evaluate SAR map).

## Identifying the Gaps for a Better System

What the program learned through the mission decomposition effort was that it had an excellent system, but there were some gaps that needed to be fixed in order to perform the missions effectively. Addressing those shortcomings was what the program did during the Block 3 requirements freeze process, which allowed the team to focus upon those capabilities that truly mattered for mission accomplishment.

The mission decomposition effort analysis has enabled the program to answer the unknowns associated with the program and served as the foundation for what became the final Block 3 recommendations. The results were achieved by using a well-defined process that was conducted at the right time in the maturity of the technology of the aircraft systems using a holistic (Lockheed-Martin, government, warfighter, subject matter expert) IPT approach with stable subject matter experts from all the stakeholder groups. Mission performance of the F-35 actually proved to be better after going through the constrained exercise. Surprisingly, including every “desired capability” versus true mission requirement was actually a detriment to performance. To understand the depth of this success, one needed only to have attended the JSF leadership’s briefing to the senior working group and operational assessment groups, where the program received an enthusiastic round of applause.

The authors wanted to understand how the mission decomposition efforts aligned to the overall progress of the JSF and elicited the thoughts of Air Force Maj. Gen. Charles R. Davis, PEO F-35 Lighting II. In Davis’s opinion, “There are some lessons we learned at F-35 that are applicable to other programs. First, we had to be brutally honest with ourselves about what performance could be attained in our final SDD capability growth increment within cost and schedule constraints. Next, we saw enormous benefit from the Lockheed-Martin cross-IPT team and consistent warfighter participation. The final key ingredients were a systems engineering process that was uncompromising in its thoroughness, and leadership both in government and industry prepared to deal with good news and bad. The mission decomposition analysis team stands out among the F-35 program’s more notable recent successes. We believe the attributes that made it a success have broad application in other acquisition programs. While mission decomposition was largely a paper exercise, decisions were validated recently in a full-up, joint, man-in-the-loop graduation virtual simulated event.”

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